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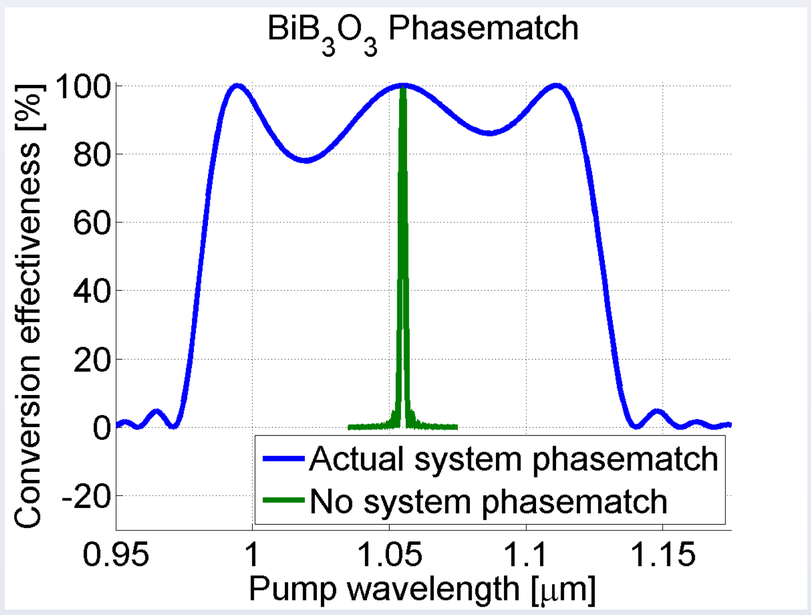
Abstract

We present a simple, passive and static setup for broadband frequency conversion.

By using simple optical components like lenses, mirrors and gratings, we obtain the spectral angular dispersion to match the second harmonic generation phasematching angles in a nonlinear BiBO crystal.

We are able to frequency double a single-frequency diode laser, tunable in the 1020-1090 nm range, with almost equal efficiency for all wavelengths.

In the experimental setup, the width of the phasematch was increased with a factor of 50.



The method can easily be extended to other wavelength ranges and nonlinear crystals.

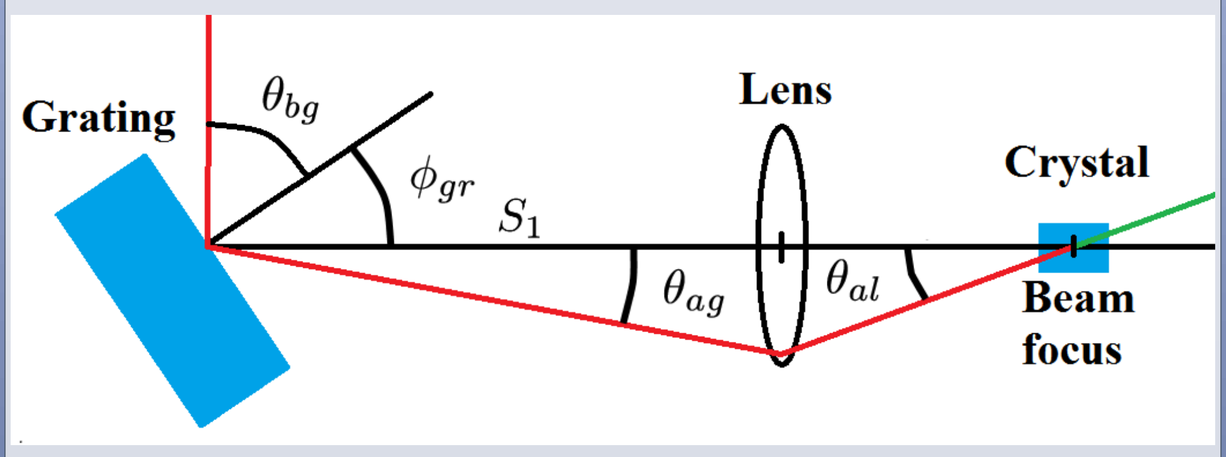
Broadband phasematching has a number of applications:

Nonlinear conversion of a swept source for optical coherence tomography.

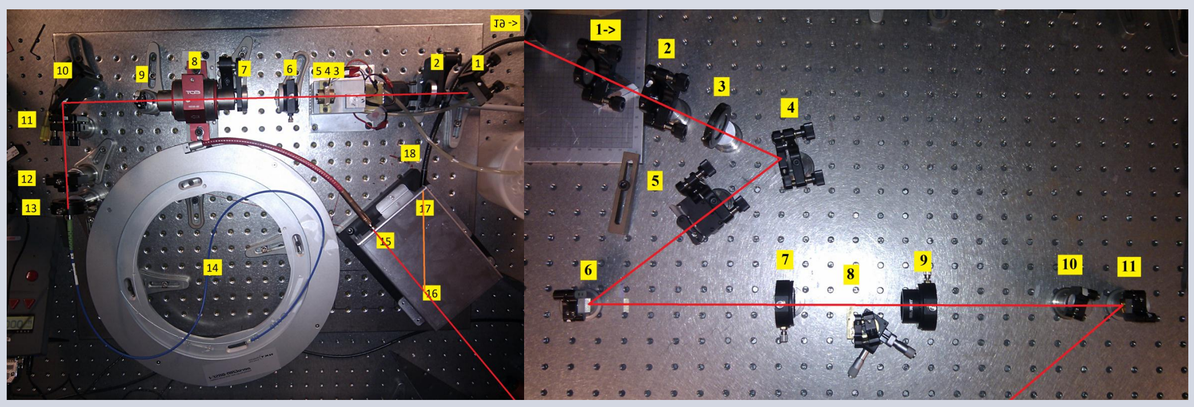
Inclusion in an autocorrelator, enabling it to use longer crystals and shorter pulses, thereby improving the SNR.

Converting some of the spectrum from a supercontinuum source, to extend its spectral range.

Setup diagram



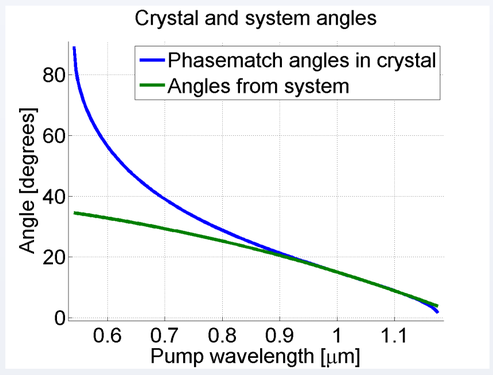
Setup pictures: The pump laser and the conversion setup

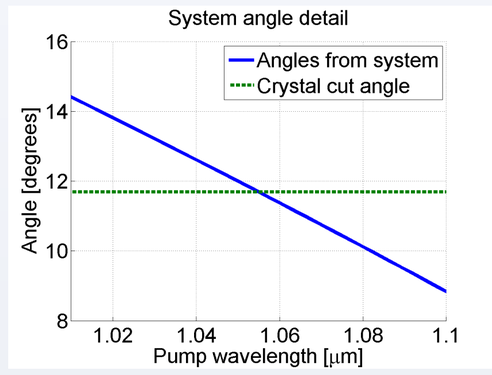


Obtaining the spectral angular dispersion

- The grating diffracts the light into angles according to its wavelengths
- The lens collects and focuses the light into the nonlinear BiBO3 crystal, with the correct phasematching angle for each wavelength
- The crystal converts some of the light to double frequency.
- A symmetrical arrangement can collect the light again

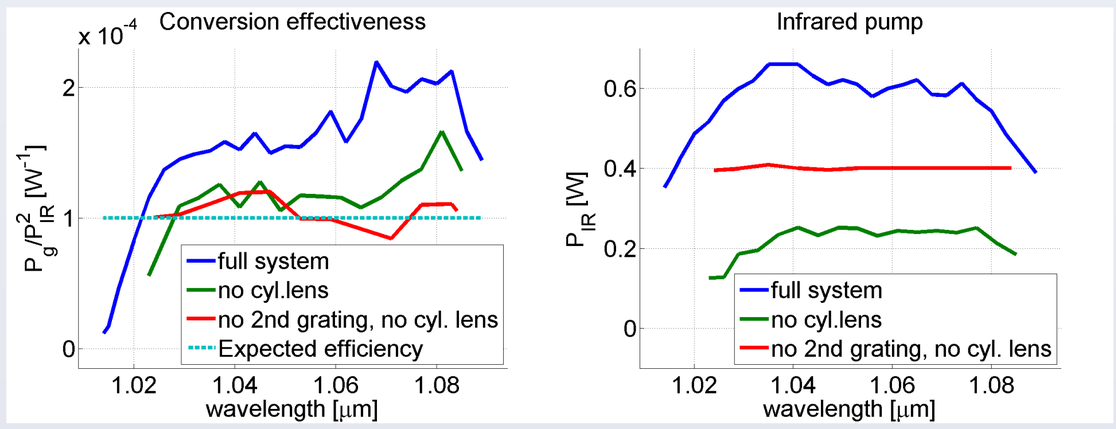
$$\theta_{al}(r_{Sf}, \theta_{bg}, \lambda_p, \lambda_c, d) = \arctan((1 - r_{Sf}) \tan(\arcsin(\sin(\theta_{bg}) - \lambda_p/d) + \phi_{gr}(\theta_{bg}))$$





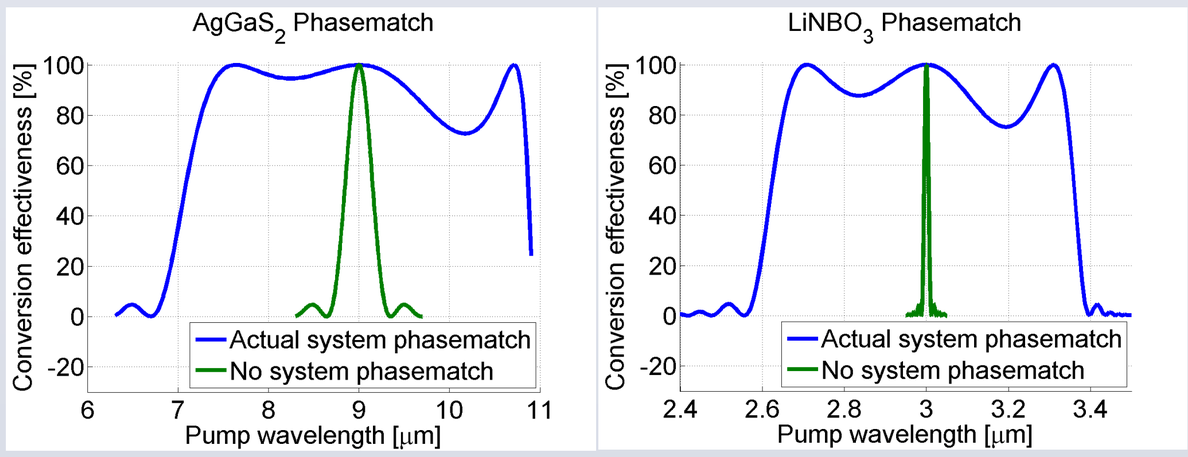
Expected efficiency and results

- With Boyd Kleinman theory[6], the expected efficiency was calculated to be approx. 0.1 mW/W^2
- Our actual efficiency deviated because of changes in the spot size
- Note the agreement in conversion efficiency, despite the large differences in pump power between series
- Efficiency can be improved with higher pump power and longer crystals



Perspectives and applications

- The setup is simple, passive and static, which makes it ideal whenever it is necessary to phasematch a broad range of wavelengths simultaneously
- BiBO is not the only crystal that can do broadband phasematching. A cursory search found suitable regions in $AgGaS_2$ [8] and $LiNBO_3$ [3]



Challenges

- The internal phasematching angles must be approx. linear as function of wavelength
- The second derivative of the spectral angular dispersion must have the same sign as the first derivative, but this is only an issue with large wavelength ranges

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[8] The EKSMA Optics Crystals Selection Guide